

Pallas physical properties revisited

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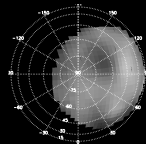
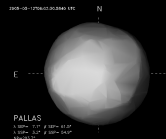
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³University of Helsinki

⁴IMCCE-CNRS, Observatoire de Paris

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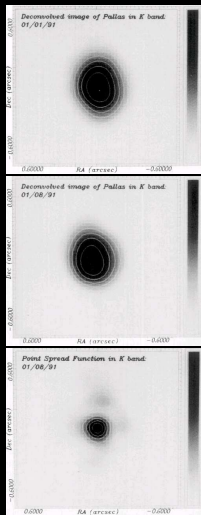
⁶Southwest Research Institute

⁷Keck Observatory

⁸ONERA

⁹Air Force Research Laboratory

Introduction



▷ why AO on big asteroids?

- Pole
- Dimensions
- Surface marking
- Density

▷ why Pallas?

- ~7% MB mass
- B-type archetype
- Almost **not** studied

Saint-Pé et al., Icarus, 1993

Observations



Date	α ($^{\circ}$)	ϕ ($''$)	SEP $_{\lambda}$ ($^{\circ}$)	SEP $_{\phi}$ ($^{\circ}$)
2003 Oct 10	9.4	0.44	18	-70
2003 Oct 12	9.4	0.44	47/138	-70
2005 Feb 02	22.1	0.49	115/188	+64
2005 Mar 12	7.2	0.57	335	+62
2005 Mar 13	7.2	0.57	13	+61
2005 May 08	20.0	0.44	234	+49
2005 May 09	20.2	0.44	220	+49
2006 Aug 16	15.5	0.28	210-321	+33
2007 Jul 12	15.6	0.29	175	-37
2007 Nov 01	16.9	0.30	153/227	-24

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== Pallas at Near-Infrared Wavelengths ==

K-band



0,-70

K-band



130,63

K-band



165,63

K-band



280,63

H-band



3,63

H-band



133,63

H-band



167,63

H-band



300,63

J-band



5,63

J-band



170,63

== Pallas at Near-Infrared Wavelengths ==



338,+33



314,+33



297,+33



277,+33



254,+33



252,+33



240,+33



225,+33

Shape derivation

① Contour extraction

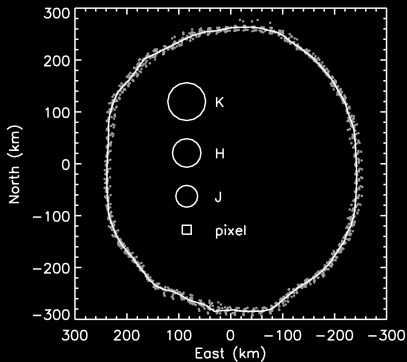
- Low probability of artifacts
- Reliability of measurements

② Combination with lightcurves

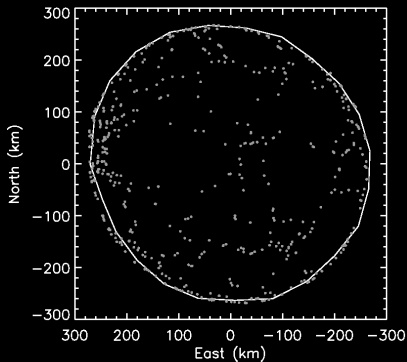
Lightcurves provide information on the shape of the object, but are not as reliable as contour extraction. They are also more sensitive to the orientation of the object and the distance to the observer.

③ Pole Solution

The pole solution is a method to determine the orientation of the object by comparing the observed lightcurves with the theoretical ones.



Shape derivation



① Contour extraction

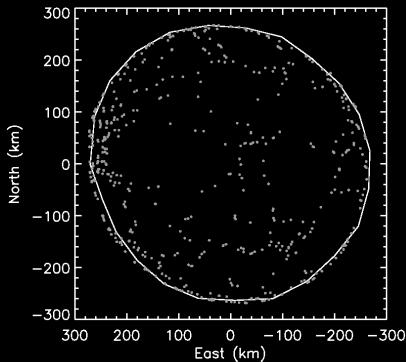
- Low probability of artifacts
- Reliability of measurements

② Combination with lightcurves

- Long-term information
- Direct measurement constrains
 - ▷ Refine shape model
 - ▷ Scale shape model

③ Pole Solution

Shape derivation



① Contour extraction

- Low probability of artifacts
- Reliability of measurements

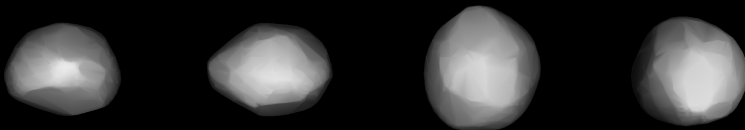
② Combination with lightcurves

- Long-term information
- Direct measurement constrains
 - ▷ Refine shape model
 - ▷ Scale shape model

③ Pole Solution

- ▷ Remove pole ambiguity
- ▷ $\lambda = +34^\circ$
 $\beta = -11^\circ$

Pallas Physical properties

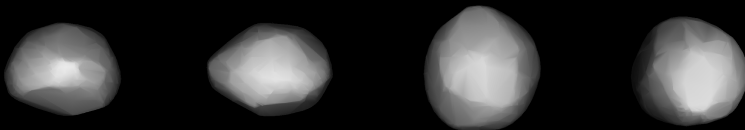


	a (km)	b (km)	c (km)	R (km)
σ	7	6	6	6
^a Value	276	266	244	262
^b Value	291	278	250	272
σ	9	9	9	9

^a current study

^b Schmidt *et al.*, ACM #83.18

Pallas Physical properties

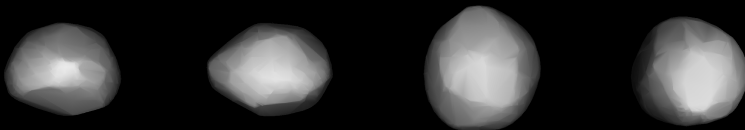


	a (km)	b (km)	c (km)	R (km)	Pixel (km)	Θ (km)
σ	7	6	6	6		
^a Value	276	266	244	262	13-25	32-90
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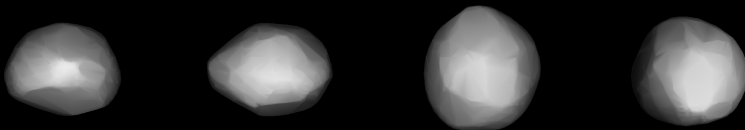
	a (km)	b (km)	c (km)	R (km)	Pixel (km)	Θ (km)	V (Gm ³)
σ	7	6	6	6			5
^a Value	276	266	244	262	13-25	32-90	65
^b Value	291	278	250	272	70	47-114	85
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Almost 25% of difference!

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Note without shape model: 75 Gm³ (13% diff)

Pallas Density

1999, AJ, Hilton	1.59 ± 0.05	
2000, A&A, Michalak	1.2 ± 0.3	
2001, A&A, Goffin	1.17 ± 0.03	
2001, Standish	1.08 ± 0.04	[from Hilton in Asteroids III]
2008, A&A, Fienga <i>et al.</i>	1.025 ± 0.025	
2001, A&A, Pitjeva	1.00 ± 0.01	
	1.095 ± 0.028	$\times 10^{-10} M_{\odot}$

$$\rho = 3.4 \pm 0.2$$

Ceres: $\rho = 2.2 \pm 0.1$ [Carry *et al.*, A&A, 2008]

Vesta: $\rho = 3.7 \pm 0.5$ [Thomas *et al.*, Science, 1997]

Pallas Density

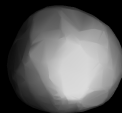
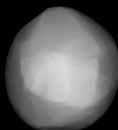
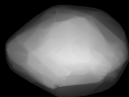
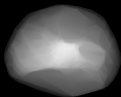
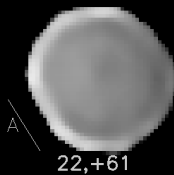
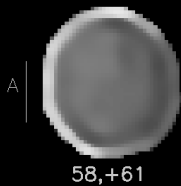
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Impact crater



Pallas family

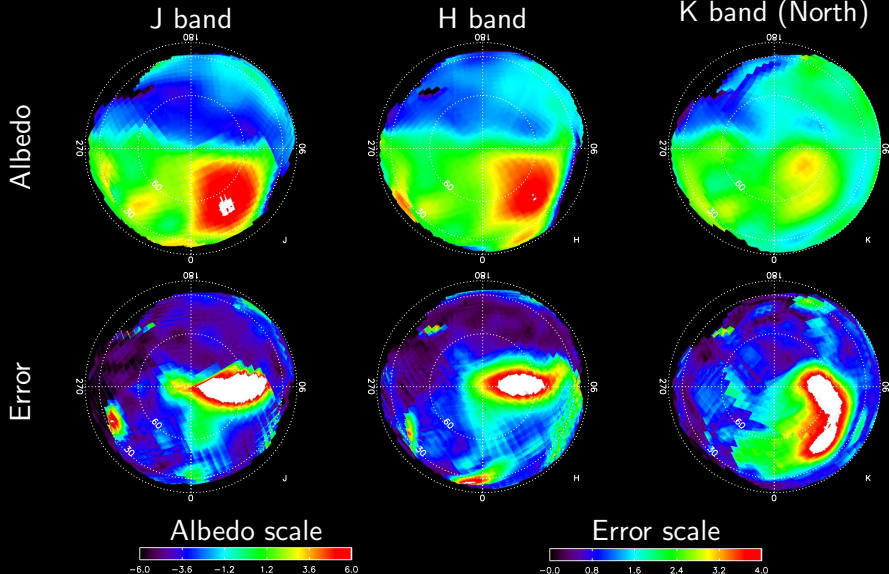
IAU #	H	q	Class	Φ (km)	V (km ³)	V (%)
5222	11.1	0.146	B	20	4194	22.4
2382	11.1	0.158	B	19	4137	44.4
5330	11.9	0.223	B	13	1332	51.5
5234	12.0	0.158	B	13	1260	58.3
531	12.1	0.146	B	12	1068	64.0
33750	12.4	<i>N.A.</i>	<i>N.A.</i>	11	725	67.8
87306	12.5	...				
					18 748	

35 candidates

0.02% of Pallas volume

Consistent with a 2-8 km depth crater

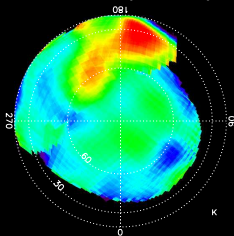
Near-infrared maps: North



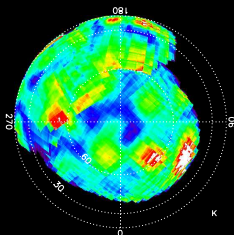
Near-infrared maps: South

K band (South)

Albedo



Error

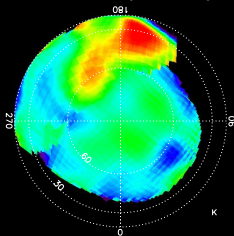


	J	H	K
Frames	56	76	169
Surface			
North (%)	85	90	92
South (%)			50
Total (%)	43	45	70
Albedo (%)	+4 -6	+4 -7	+3 -8
Error (%)	< 4	< 4	< 4

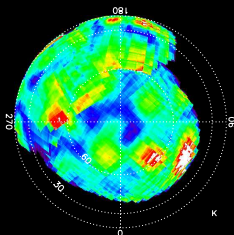
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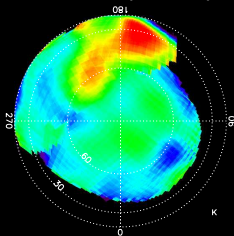


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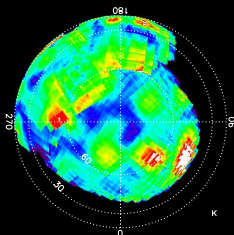
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Summary

① Spin Vector

- ECJ2000.0 ($\lambda = 34^\circ$, $\beta = -11^\circ$) $\pm 5^\circ$

② Size & Shape

- $275 \times 265 \times 242 \pm 7 \times 6 \times 6$ km
- Model with 2000+ facets consistent with AO and LC

③ Density

- $\rho = 3.7 \pm 0.5$
- Mass ? Volume ?

④ Albedo

- Few percent variation
- Spectral resolution too low for constituent analysis

Summary

